most interesting in point of size, no sufficient character has yet been given which would separate them into different species. Indeed the very characters most insisted upon are those which seem most certainly to point to their identity with *D. nitida*, Verrill.

Distichopora coccinea, Gray.

In his monograph of the genus, the Rev. J. E. Tenison-Woods has given a figure of this species, and states that he does not think the species has yet been figured. It may be pointed out that when the species was described by Dr. Gray it was also figured (Proc. Zool. Soc. 1860).

XIV.—*Contributions to Micro-Palæontology.—Notes on some Species of Monticuliporoid Corals from the Upper Silurian Rocks of Britain.* By H. Alleyne Nicholson, M.D., D.Sc., Regius Professor of Natural History in the University of Aberdeen.

[Plate VII.]

It has long been my intention to give a detailed account of the microscopic structure of the Monticuliporoid Corals of the Wenlock Limestone of Britain, so far as known to me. I have found, however, that the accomplishment of this would demand more time than is at present at my disposal; and I therefore, in the meanwhile, publish the following notes on the minute structure of some of the commoner Wenlock Monticuliporoids*, in the hope that they may prove useful to other workers in the same field. From the brief descriptions and accompanying figures of structure, it will, I think, be found easy to recognize the types which I have had under observation, and this is the special object which I have had in view. On the other hand, I have found great difficulties as to the nomenclature of the forms here described, and I have not been able to clear up these difficulties to any extent. The earlier observers of these fossils, as, for example, Mr. Lonsdale, necessarily founded their names upon macroscopic cha-

* Besides certain ramose Monticuliporoids which I have as yet imperfectly examined, the Wenlock Limestone contains various incrusting forms (such, for example, as the curious type figured by Milne-Edwards and Haime under the name of *Monticulipora papillata*), which require for their elucidation a more detailed investigation than I have hitherto been able to undertake.

racters principally, the method of investigation by means of thin sections being of recent origin; and they also gave, as a rule, extremely brief descriptions. Hence it is exceedingly difficult, in many cases, among the Monticuliporoids, to be certain as to the precise forms to which the older names should be attached. In the following notes, therefore, I have not employed any of the older specific names, except in cases where I can do so with tolerable certainty of being correct in so doing. Those forms which I cannot satisfactorily identify with previously described species I have provisionally designated by new titles, though it is quite possible that some of these will also prove to be referable to species to which names have been attached at some earlier date.

1. *Fistulipora crassa*, Lonsd. sp. (Pl. VII. figs. 1, 1 *a*, 2, 2*a*.)

Heteropora crassa, Lonsdale, Sil. Syst. pl. xv. figs. 14, 14 *a* (1839).

The corallum in this species is ramose, the branches being rounded or somewhat compressed, mostly solid, and varying in diameter from about one line up to half an inch. The surface appears to be smooth, and devoid of either monticules or maculæ, so far as I have seen. The tube-mouths are usually distinctly, though slightly, elevated above the general surface, and are surrounded by a distinct ring, though in some exceedingly well-preserved specimens these features are not observable. The interstitial tubules may or may not be superficially recognizable. In thin tangential sections (Pl. VII. figs. 1 & 2) the corallites are seen to be oval or circular, not markedly pinched in or indented at any point, and varying in size in different specimens, being mostly between $\frac{1}{100}$ and $\frac{1}{80}$ inch in diameter (generally nearer the latter). In one section I have examined (fig. 2) two of the corallites are seen to be connected by a lateral tube of communication. The interspaces between the corallites are rarely more than $\frac{1}{120}$ inch in diameter, and they are occupied by interstitial tubuli, which are polygonal or angular in shape, with imperfect walls. Mostly only a single row of such tubuli separates any pair of contiguous corallites, but two rows are also often seen in places. In long sections (Pl. VII. figs. 1 *a* and 2 *a*) the corallites are seen to be crossed by a few complete and approximately horizontal tabulæ; while the interspaces between them are occupied by vesicular tissue formed by the anastomosis of the tabulæ of the interstitial tubules. No "spiniform corallites" appear to be present.

It is, perhaps, open to question whether Lonsdale's figure and description of *Heteropora crassa* really apply to this

form, and not rather to the very similar *F. ludensis*, which I shall describe immediately.

If, however, Lonsdale's title is to be retained, it is best to keep it for the form which has been usually regarded by observers as *Heteropora crassa*. There is no doubt as to the propriety of the reference of this form to *Fistulipora*, M'Coy, as shown by the in general complete isolation of the corallites, and the fact that the walls of the interstitial tubules are so imperfect as to allow of a confluence of their tabulæ, and the consequent production of an intermediate vesicular tissue.

Fistulipora crassa is most nearly allied to *F. ludensis*, Nich., from which it is distinguished by its not forming thin crusts, by the generally projecting mouths of the corallites and their larger size, by the larger size and smaller number of the interstitial tubuli, as well as by their incomplete walls, and, lastly, by the want of "spiniform tubuli."

Formation and Locality. Wenlock Limestone, Dudley, Benthall Edge, Dormington.

2. *Fistulipora ludensis*, Nich. (Pl. VII. figs. 3–3 *b*.)

The corallum in this species forms thin crusts, from half a line to three quarters of a line in thickness, growing upon foreign objects. The surface is smooth, without definite maculæ or monticules, and exhibits the circular openings of the ordinary corallites, surrounded by very numerous minute interstitial pores. As seen in tangential sections (Pl. VII. fig. 3), the corallites are seen to be circular or oval, often indented at one point, or at two points, and about $\frac{1}{100}$ inch in diameter. The corallites are in general completely isolated, and are separated by one, two, or three rows of very minute interstitial tubuli, which are subpolygonal in shape, and have tolerably complete walls. As just mentioned, the wall of the visceral chambers of the corallites is often bent inwards on one side or at more than one point, and at such points "spiniform tubuli" are usually developed (Pl. VII. fig. 3 *a*). Similar spiniform tubuli may also be sparingly developed among the ordinary interstitial tubuli. As seen in long sections (Pl. VII. fig. 3 *b*), the corallum is seen to be built up of successively superimposed thin strata of tubes. The proper corallites are crossed by a few remote, complete, horizontal tabulæ; while the interstitial tubules have more closely set tabulæ, which are so disposed as to give rise in the longitudinal section to a sort of vesicular interstitial tissue.

The present species is in many respects very similar to *Fistulipora crassa*, Lonsd., sp.; and it is quite possible that Mr. Lonsdale may have had this form, at any rate partly, in

view in describing his *Heteropora crassa*. As regards its general characters, it is distinguished from *F. crassa* by its habit of growth, and also by the much greater development of the interstitial tubuli, which give to the surface of well-preserved specimens a minutely porous appearance. Moreover, the mouths of the corallites are not surrounded by prominent rims. As regards internal structure, the chief features which distinguish *F. ludensis* from *F. crassa* are the greater number of the interstitial tubes and their more complete walls, the smaller size of the ordinary corallites and their more complete isolation, and the presence of well-marked "spiniform tubuli."

Formation and Locality. Wenlock Limestone, Dudley. The best preserved specimen I have seen forms a thin crust growing upon a specimen of *Monticulipora pulchella*, E. & H., which it entirely envelops.

3. *Callopora nana*, Nich. (Pl. VII. figs. 4–4 *b*.)

The corallum in this species is in the form of minute, cylindrical, or bulbous masses, generally two or three lines in length, and about a line or a line and a half in diameter. The surface is free from monticules or maculæ, but exhibits the openings of the large circular or oval corallites, largely or wholly separated by irregular, often oblong interstitial pores. In tangential sections (Pl. VII. fig. 4 *a*) the corallites are seen to be oval or subcircular, averaging about $\frac{1}{50}$ inch in their long diameter, which corresponds in direction with the long axis of the corallum. They are separated by intervals occupied by the interstitial tubes, which have quite complete walls, and are mostly long-oval or irregularly oblong in shape. The long diameters of the interstitial tubes correspond with the long axis of the corallum, and vary from $\frac{1}{100}$ inch to $\frac{1}{60}$ inch, their shorter diameters being from $\frac{1}{125}$ to $\frac{1}{150}$ inch. Hence the intervals separating contiguous corallites are much greater in the direction of the long axis of the coral than when measured transversely to the corallum.

In long sections (Pl. VII. fig. 4 *b*) the corallum is seen to be composed of tubes which are vertical in the axis of the colony, and then gradually bend outwards to open on the surface. They are similar in internal structure throughout their entire extent, complete horizontal tabulæ being largely developed both in the axial region and the peripheral region, while their walls have a nearly uniform thickness throughout. As they bend outwards, however, towards the

surface, the corallites become separated by the development of the interstitial tubes, which entirely resemble the proper corallites in structure, except in the fact that they possess a much larger number of tabulæ, these structures, however, being still horizontal and complete, and not assuming a vesicular character.

As regards the generic position of this species, I find it necessary to make a few remarks, as I have elsewhere (Pal. Tab. Cor. p. 304) expressed the opinion that *Callopora*, Hall, should be regarded as a synonym of *Fistulipora*, M'Coy. I arrived at this view from a study of the description and figures given by Prof. Hall of *Callopora*, from an examination of M'Coy's type species of *Fistulipora*, and from an investigation of various corals which appeared to be precisely similar to various forms included by Prof. Hall under *Callopora*. That *Callopora*, Hall, has been made by its original founder, as well as by other palæontologists, to include a large number of heterogeneous forms, and that some of these are truly referable to *Fistulipora*, M'Coy, are points which appear to me to be free from doubt, and it was therefore not unnatural that I should have concluded that the two genera were identical.

Recently, however, this question has been attacked in a more satisfactory manner by Mr. Ulrich (Journ. Cincinn. Soc. Nat. Hist. 1882), who has had the opportunity of examining by means of thin sections authentic specimens of *Callopora elegantula*, Hall, which is the type species of the genus *Callopora*, Hall. Mr. Ulrich has shown that this species differs in its structure from the majority of the numerous forms referred by Prof. Hall to *Callopora*, and that it exhibits characters entirely similar to those of various Monticuliporoids which I included under the name of *Heterotrypa*, and certainly quite unlike those of *Fistulipora*, M'Coy. While I am not prepared to admit the justice of all the remarks which Mr. Ulrich has seen fit to make upon this subject, I am quite ready to recognize the new light which he has thus thrown upon the structure and affinities of *Callopora*, Hall. I also quite recognize that *Heterotrypa*, as originally defined by me, is a wide group which may be advantageously subdivided. For these reasons, therefore, I shall accept the genus *Callopora*, Hall, as defined by Mr. Ulrich, as including Monticuliporoids of the type of the present species, with numerous interstitial tubes, which resemble the normal corallites in all except their size and their possession of more numerous tabulæ. The corallites, moreover, are always rounded, and their walls are amalgamated.

The nearest allies of *Callopora nana*, so far as I know at present, are *C.* (*Heterotrypa*) *O'Nealli*, James, and *C.* (*Heterotrypa*) *nodulata*, Nich., both of which are found in the Cincinnati group of North America. From both of these forms, however, the present species is distinguished by well-marked external and internal peculiarities, its distinguishing features being its small dimensions, the proportionately large size of the corallites, and the peculiar elongated form of the interstitial tubes, while a marked internal feature is the very extensive development of the tabulæ in not only the peripheral but also the axial region of the corallites.

Formation and Locality. Wenlock Limestone, Benthall Edge; Wenlock Shales, Buildwas.

4. *Callopora Fletcheri*, E. & H. (Pl. VII. figs. 5–5 *b*.)

Monticulipora Fletcheri, Edwards & Haime, Brit. Foss. Corals, p. 267, pl. lxii. figs. 3, 3 *a*.

Corallum ramose, of cylindrical branches, which have a diameter of from a line and a half to two lines and a half. There are no proper monticules or maculæ; but the surface shows the approximately circular apertures of the ordinary corallites, the diameter of which is about $\frac{1}{60}$ inch. The corallites are separated by interspaces of from $\frac{1}{250}$ to $\frac{1}{125}$ inch in diameter, and in badly-preserved specimens these interspaces either appear as solid or show only here and there a minute polygonal opening. On the other hand, in well-preserved examples the intervals between the ordinary corallites are seen to be wholly occupied by the openings of interstitial tubuli. In tangential sections (Pl. VII. fig. 5 *a*) the corallites are seen to be thick-walled and circular, with a well-defined internal boundary, though not showing the peculiar dark marginal ring which is so characteristic of many species of *Callopora*. Occasionally minute tooth-like processes, which look like septa, project into the visceral chamber, though I have never seen more than two or three of these in a single corallite. The walls of the corallites are amalgamated with those of the interstitial tubes, and there is rarely more than a single row of the latter, while in places the corallites are actually in contact. The interstitial tubes are rounded or polygonal, and only rarely have an elongated form. In long sections (Pl. VII. fig. 5 *b*) the ordinary corallites are seen to be provided abundantly with complete horizontal tabulæ, both in the axial and the peripheral region of the corallum. As they proceed outwards from the centre to the circumference of the branches, they bend at a considerable angle, and their walls become at the same time considerably thickened. The interstitial

tubules altogether resemble the normal corallites in structure, except that they are provided with much more numerous tabulæ. Moreover, in old examples the interstitial tubules become largely filled up with secondary deposit, so that their cavities become largely or wholly obliterated.

I feel very doubtful as to whether or not I am correct in identifying the present species with the *Monticulipora Fletcheri* of Edwards and Haime. After an examination, however, of a very large number of specimens I have come to the conclusion that these observers probably founded the above-mentioned species upon an example of the form which I have just described, in which the surface was not sufficiently well preserved to show more than a few of the larger interstitial tubes. At any rate, if this conclusion be incorrect, I know of no other similarly shaped and sized coral in the Wenlock Limestone which would show the same circular calices separated by well-marked interspaces.

In various structural features *Callopora Fletcheri* shows a resemblance to *C. nana*, Nich.; but it is distinguished by its generally much larger dimensions, the circular shape and thick walls of the corallites, and the polygonal form and small size of the interstitial tubules. Internally the present species is at once distinguished by the thickening of the walls of the tubes, which in old specimens is sometimes carried so far as to almost entirely fill up and obliterate the interstitial tubes.

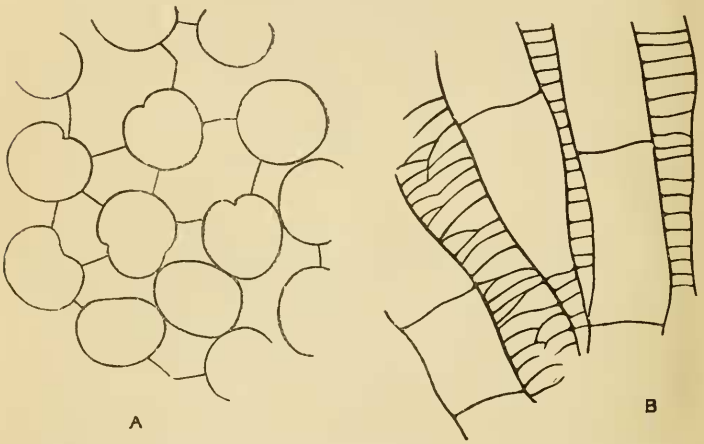
Formation and Locality. Not uncommon in the Wenlock Limestone of Benthall Edge and Dormington.

5. *Callopora? glans*, Nich. (Fig. 1 and Pl. VII. fig. 6.)

The corallum in this species is of small size, generally about four or five lines in greatest height and width, and mostly subspherical, hemispherical, or pyriform in shape. Sometimes a basal epitheca is developed; but at other times the corallum is apparently destitute of this structure, its under surface, except the peduncle of attachment, being covered by the calices. The surface shows no monticules or maculæ, and is covered with the large circular openings of the corallites, with the well-marked apertures of the minute interstitial tubes between them. As seen in tangential sections (fig. 1, A) the corallites are provided with very thin and delicate walls, and have a diameter of about $\frac{1}{50}$ inch. They are approximately circular, but their wall is generally bent inwards at one or more points into a kind of pseudo-septal fold, giving the visceral chamber a heart-shaped form. In other cases there are two of these infoldings of the wall, generally placed

opposite each other. The corallites often touch at points, but they are mostly separated by narrow interspaces occupied by a single row of large, angular, imperfectly walled interstitial tubes. As seen in long sections (fig. 1, B) the ordinary corallites are crossed by a few remote and complete tabulæ, and the interstitial tubes are provided with numerous horizontal tabulæ, which at times anastomose and become subvesicular.

Fig. 1.



Callopora ? glans, Nich. A, tangential section, enlarged twenty times; B, longitudinal section, similarly enlarged.

I am indebted for specimens of this curious species to the kindness of Mr. Madeley, of Dudley. It is of interest as forming in some respects a transition between the proper *Fistuliporæ* and the typical species of *Callopora*. This is shown both in the infolding of the walls of the corallites, which is such a characteristic feature of the species, and also in the fact that the walls of the interstitial tubes are so imperfect as commonly to allow of a confluence of their tabulæ, giving rise to a partially vesicular interstitial tissue. *Callopora? glans* has some resemblances to one of the numerous Russian Monticuliporoids which have the general form of *Monticulipora petropolitana*; but I know of no form with which it could be confounded.

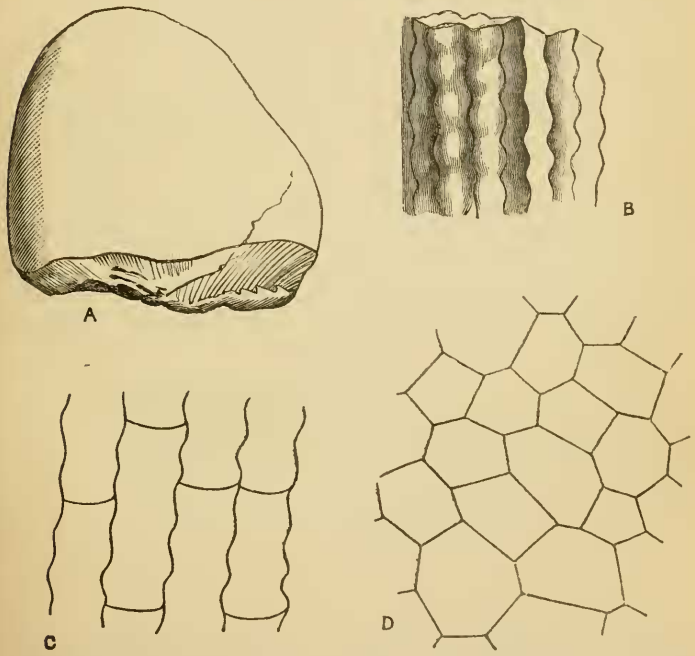
Formation and Locality. Lower Ludlow shales, Sedgeley.

6. *Monotrypa crenulata*, Nich. (Fig. 2.)

The corallum in this species is hemispherical or subglobu-

lar, ordinary examples having a height of an inch or an inch and a half, and a diameter of about the same at the base. The base is flat or concave, and is covered by a striated epitheca; and the corallites radiate from the base to open over the whole convex upper surface of the colony. The corallites are prismatic, mostly pentagonal, thin-walled, and not firmly united with one another, their walls being regularly and uniformly crenulated in such a manner that contiguous tubes are accurately dovetailed together. The corallites vary in size from about $\frac{1}{50}$ inch up to $\frac{1}{35}$ inch, there being occasionally definitely defined groups of the larger tubes. No spiniform tubuli are developed. The surface is apparently smooth and devoid of

Fig. 2.



Monotrypa crenulata, Nich. A, outline of a specimen, of the natural size; B, part of a few tubes, enlarged; C, longitudinal section, enlarged twenty times; D, tangential section, similarly enlarged.

monticules. As seen in long sections the tubes are found to be crossed at considerable intervals ($\frac{1}{25}$ to $\frac{1}{10}$ inch) by a few horizontal tabulæ, which are not uniformly placed at corresponding levels in contiguous corallites.

I think it tolerably certain that this form corresponds with part of the *Favosites fibrosa* of Mr. Lonsdale (Sil. Syst. pl. xv. *bis*, figs. 6–6 *d*); and I should very willingly have retained the specific name of *fibrosa* if this had seemed at all advisable. The name of *Favosites fibrosa* has, however, been given by different authors to very different corals *, and the specific name can only be retained for the form to which Goldfuss originally applied this title, whatever that may really be. The widest differences also have existed among British palæontologists in their descriptions of the characters and structure of the forms to which this name has been given. Thus Mr. Lonsdale both figures and describes mural pores in some of the forms which he placed under *Favosites fibrosa*, whereas M'Coy expresses his conviction that mural pores are wanting, and places the forms which he considers Lonsdale to have had in view under *Stenopora*, retaining for them the specific name of Goldfuss. Again, it seems certain that Milne-Edwards and Haime, in their great work on the British Fossil Corals, included two quite distinct types, one from the Devonian and the other from the Silurian, under the name of *Favosites fibrosa*. Upon the whole, therefore, it has appeared to me to be safest to give a new name to the forms now under consideration, even though they should prove to be what Lonsdale regarded as *Favosites fibrosa*, Goldf.

As to the generic position of this type, I have failed to convince myself that it possesses mural pores. The shape of the tubes reminds one of what one sees in some species of *Favosites*, such as *F. aspera*, D'Orb., and *F. mullochensis*, Nich. and Eth., and one naturally expects to find foramina on the crenulated angles of the corallites. Moreover, I have occasionally seen phenomena which I should have regarded as probably indicating the presence of mural pores, had I been able to look only at rough fractures of the coral with a comparatively low magnifying-power. If mural pores really

* If we take the description of *Favosites fibrosa*, Goldf., given by Milne-Edwards & Haime (Pol. Foss. p. 244) we find at once that it cannot possibly be the same as the form here under consideration, since (quite apart from the question of the presence or absence of mural pores) the tabulæ are stated to be very close-set (five or six in the space of a millimetre). Similarly the close-set tabulæ, as well as the want of crenulated corallites, will show that the form figured by these same authors from the Devonian of Devonshire as *F. fibrosa*, Goldf. (Brit. Foss. Cor. pl. xlviii. figs. 3–3 *b*), cannot be identical with the present type. On the other hand, the coral figured by Milne-Edwards and Haime under the same name from the Upper Silurian of Britain (Brit. Foss. Cor. pl. lxi. figs. 5, 5 *a*) does really seem to be identical with the form which I have here described.

existed, however, at the angles of the tubes (where alone in this form they could exist), they would certainly be detected in thin sections; and I have not seen any traces of such openings in either tangential or longitudinal slices. In the absence of mural pores the species must be referred to the genus *Monotrypa*, Nich., and it is, indeed, in many respects closely allied to the *Monotrypa undulata*, Nich., of the Trenton Limestone and Hudson-River formation of Canada. The principal characters, in fact, which would distinguish *M. crenulata* from the globular forms of *M. undulata*, Nich., are that the corallites of the former are, on the whole, decidedly larger than they are in the latter, that there are none of the smaller angular corallites which are found among the larger tubes in the latter species, that the thickened nodes at the angles of the larger corallites ("spiniform tubuli"?) in *M. undulata* are wholly absent in *M. crenulata*, and that the walls of the corallites in the English species are decidedly more strongly crenulated than in the Canadian type.

Formation and Locality. Wenlock Limestone, Dudley. Lower Ludlow Shale, Sedgeley (coll. Mr. Madeley).

7. *Monotrypa pulchella*, E. & H.

I have already described and figured this species ('The Genus Monticulipora,' p. 188, figs. 38, 39), and have nothing special to add, except that I find the species to be a more abundant one than I had previously supposed, fragments being not uncommon both at Benthall Edge and Dormington.

EXPLANATION OF PLATE VII.

Fig. 1. Tangential section of *Fistulipora crassa*, Lonsd., sp., enlarged twenty times.

Fig. 1 *a*. Longitudinal section of the same, similarly enlarged.

Fig. 2. Tangential section of another example of *F. crassa*, in which the corallites are of smaller size. Two of the corallites are united by a lateral connecting-tube. Enlarged twenty times.

Fig. 2 *a*. Longitudinal section of the preceding, similarly enlarged.

Fig. 3. Tangential section of *Fistulipora ludensis*, Nich., enlarged twenty times.

Fig. 3 *a*. Part of the same, enlarged fifty times, showing "spiniform tubuli."

Fig. 3 *b*. Longitudinal section of the preceding, enlarged twenty times.

Fig. 4. Outline of a specimen of *Callopora nana*, Nich., of the natural size.

Fig. 4 *a*. Tangential section of the same, enlarged twenty times.

Fig. 4 *b*. Longitudinal section of the same, similarly enlarged.

Fig. 5. Outline of a fragment of *Callopora Fletcheri*, E. & H., of the natural size.

Figs. 5 *a* & 5 *b*. Tangential and longitudinal sections of the same, enlarged twenty times.

Fig. 6. Outline of a specimen of *Callopora? glans*, Nich., of the natural size.